The Wet vs. Dry Question for Scrubbers

Alden Webinar Series

December 8, 2011

We will begin shortly

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Agenda

- Introduction - Martin Kozlak, Alden
- The Regulatory Environment and Short Overview of Scrubbing Technologies - Chris Wedig, Shaw
- Wet versus Dry FGD Case Study - Ned West, Southern Co.
- On the Choice of a Dry Scrubber for Dominion's Brayton Point Power Plant - Thomas Penna, Dominion

Introduction

Martin Kozlak

Director, Gas Flow Systems

Engineering

Alden

About Alden

- Engineering services:
  - Hydraulic Modeling & Consulting
  - Fish protection consulting and laboratory work
  - Field measurement services
  - Flow meter calibration

About Alden

- Physical and computational modeling to ensure the proper performance of gas flow systems:
  - Dry and wet scrubbers
  - Other air pollution control equipment
  - Process equipment
  - Gas turbine peripherals
  - Ventilation (pollutant, smoke, fire)

Regulatory Environment and Short Overview of Scrubbing Technologies

Chris Wedig

Senior AQCS Technology Specialist

Shaw

Regulatory Environment

- Utility MACT
  - Particulate Matter
  - Hydrogen Chloride
  - Mercury
- Cross State Air Pollution Rule (CSAPR)
  - Nitrogen Oxides
  - Sulfur Dioxide

Regulatory Environment

- Regional Haze (where applicable)
  - Particulate Matter
  - Sulfur Dioxide
  - Nitrogen Oxides
- Consent Decree (if applicable)
  - Particulate Matter
  - Sulfur Dioxide
  - Nitrogen Oxides
  - Other

Related Potential Future Regulatory Environment

- Coal Combustion Residuals (CCRs)
- GHG NSPS (potential)
- Thermal Power Plant Cooling Water Intake (316 b)
- Waste Water Discharge Issues
- Permit Renewal Process

Options to Consider

- Utilities may consider a range of options in addressing the regulatory environment.
- One of several options is to evaluate different retrofit technologies for flue gas cleaning.
- There are a variety of processes available for consideration, including “scrubbers”.

Factors Considered in Scrubber Technology Selection

- Stack emission requirements.
- Fuel type and flue gas properties.
- Site-specific technical and economic (capital and annual O&M costs)

Factors Considered in Scrubber Technology Selection (con't)

- **Site-specific technical and economic (capital and annual O&M costs)**
  - Financial factors and costs (e.g. economic life, interest rate, unit costs, etc.)
  - Size of plant,
  - Capacity factor,
  - Reagent type and usage rate,
  - Byproduct type and production rate,
  - Electrical power usage,
  - Water type and usage rate,
  - Waste water production rate and permit issues,
  - Steam requirement (if required),
  - Cooling water usage (if required),
  - Impacts on the existing draft system, stack, plant electrical distribution and other systems,

Factors Considered in Scrubber Technology Selection (con't)

- **Site-specific technical and economic (capital and annual O&M costs) (continue)**
  - Impact of the retrofit scrubber on the existing air quality control (AQC) equipment at the power plant (e.g. PAC or Trona impact on flyash),
  - Methods to dispose or reuse scrubber waste byproducts and/or conversion of scrubber by-products to useful materials,
  - Real estate required for the scrubber system equipment,
  - O&M personnel (staffing),
  - Maintenance required, including parts replacement (e.g. bag/cage),
  - Spare part requirements,
  - System reliability required,
  - Compatibility of retrofit scrubber with any future potential systems such as cooling water systems, waste water systems, solid byproduct waste landfill projects, and carbon dioxide (CO_2) capture systems,
  - Permit issues, including issues related to retrofit scrubber and byproducts.

Types of Scrubbing Technologies

- Dry Sorbent Injection (DSI with Trona, SBC, HL)
- Spray Dryer Absorber (SDA with lime, HL)
- Circulating Dry Scrubbers (CDS/NID with lime, HL)
- Wet Scrubbers (e.g. limestone, lime, etc.)
- Multi-Pollutant (e.g. ReACT, etc.)
- Other

Summary

- In addressing the Regulatory Environment, Utilities may evaluate a range of options.
- One of several options is to evaluate retrofit “scrubbers”.
- Selection of scrubber technology type is based on plant specific economic and technical considerations.

Wet vs. Dry FGD Case Study

Ned West, P.E.

Southern Company Generation

Southern Company

- 43,000 MW of generation capacity
- 73 fossil and hydro plants
- 4.3 million retail customers

Case Study - Plants A and B

- Plant A – 2 x 250MW units, no other coal-fired generation on plant site
- Plant B – 375MW + 250MW units, one larger unit on the same site has a wet scrubber

Traditional Factors – Wet vs. Dry

- Unit size
- Fuel Sulfur
- Capacity Factor
- Byproduct disposal
- Req'd SO_2 removal
- Draft system loss
- Power consumption
- Cost of lime versus limestone
- Visible steam plume
- New vs. retrofit
- Existing stack mat'l
- Flyash disposal or sales

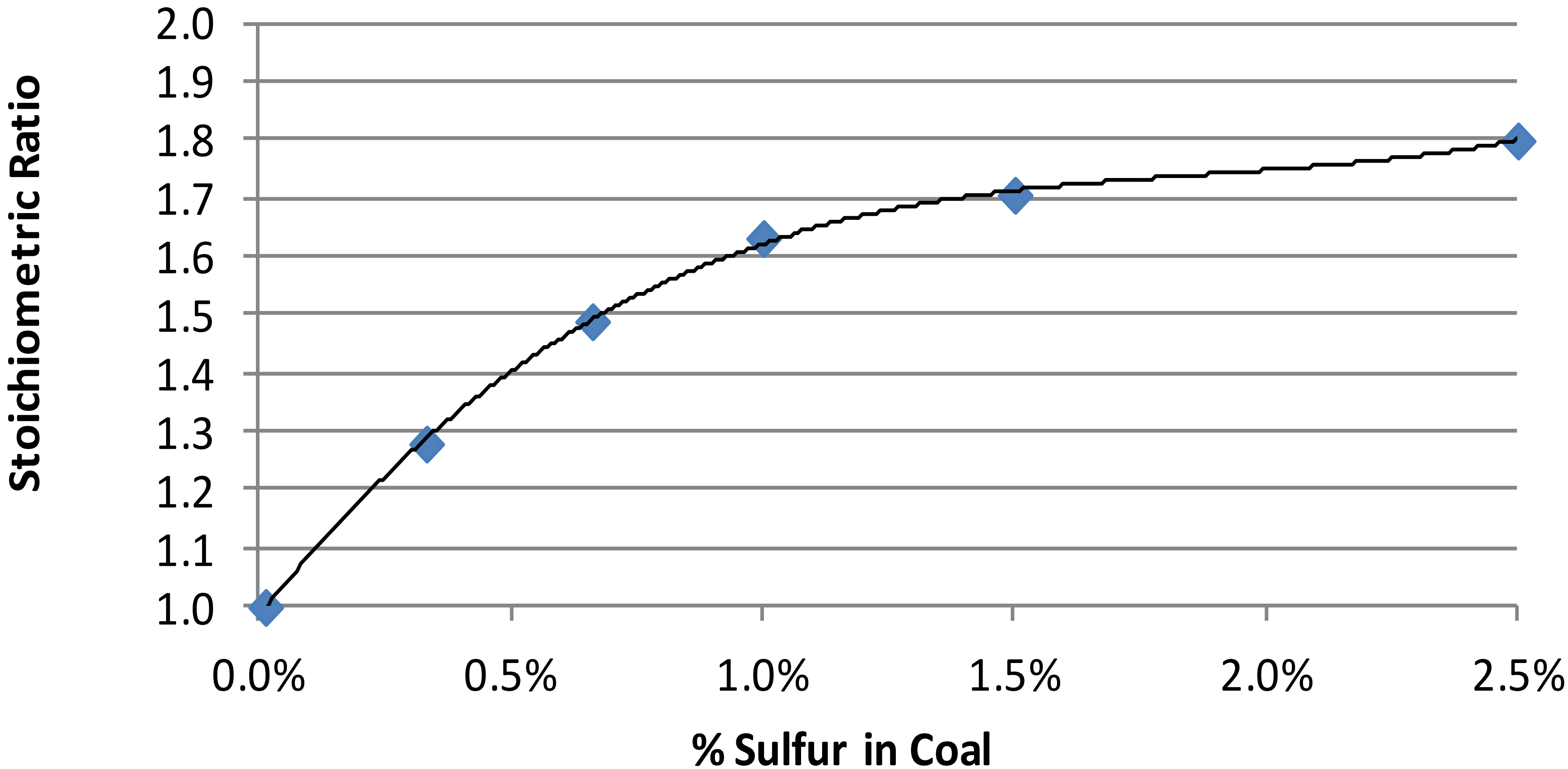
New Factors – Wet vs. Dry FGD

- HAPS MACT Compliance
  - Mercury compliance
  - Particulate emission
- Wastewater treatment
- Circulating Dry Scrubber performance
- Modularity of new designs
- Pre-ground limestone
- Dry byproduct disposal under new CCR regs

Reagent Cost Evaluation

- Depends on fuel sulfur content and reagent stoichiometric ratio
- Depends on unit capacity factor
- Relative cost of lime vs. limestone
- Ratio of lime/ LS cost per ton has changed from 6:1 to 2:1 in recent years due to our use of pre-ground limestone in some wet scrubbers

Lime vs. Fuel Sulfur for Dry FGD



Derived from proposal data

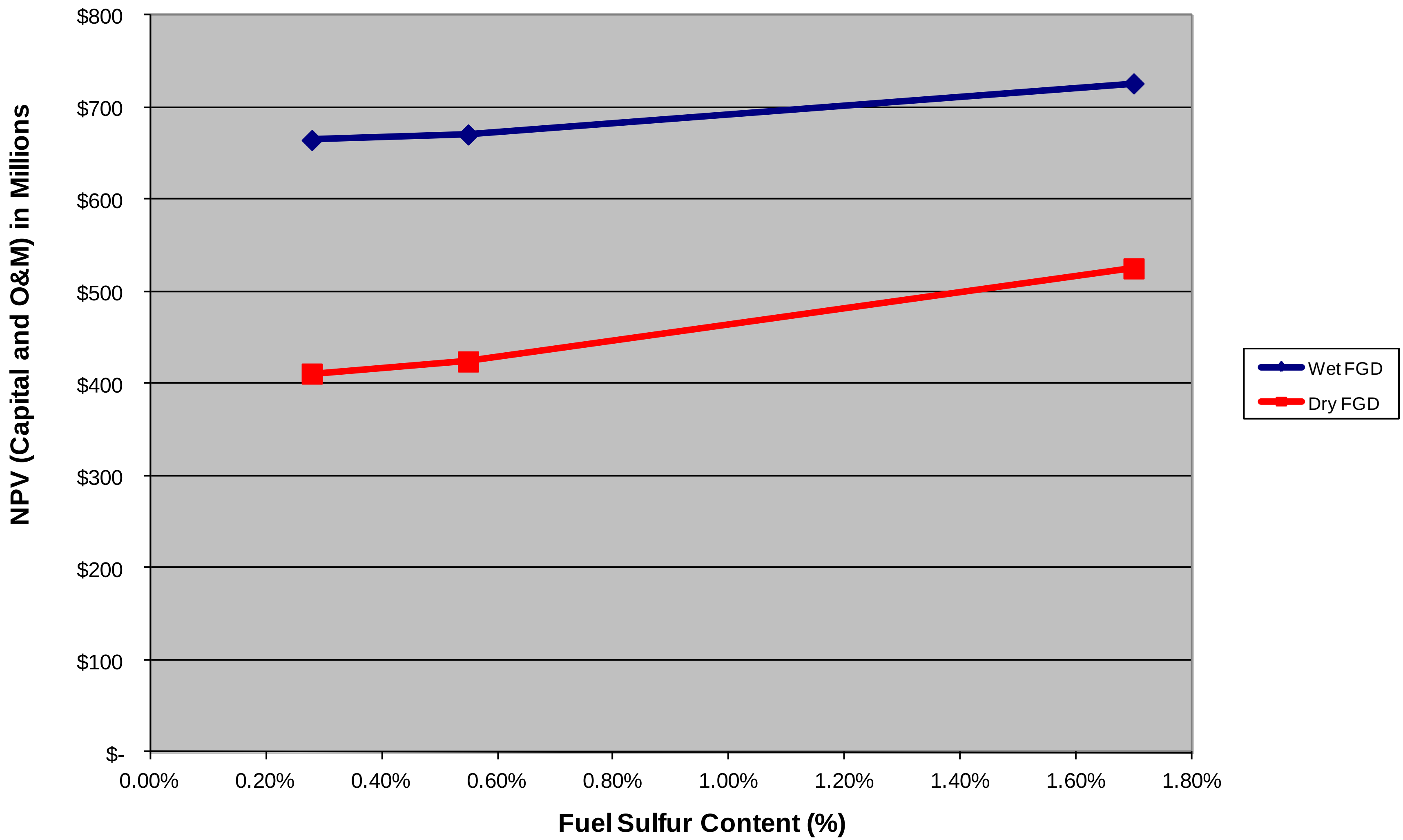
Attribute	Wet FGD	Dry FGD / FF	Importance / Priority at Plant A	Notes / Comments
Environmental Performance				
SO_2 removal, 1%S Coal	98%	98%	Important	
SO_2 removal, 2.5%S Coal	96%	96%	Important	Fuel Flexibility
SO_3 / H_2SO_4 removal	~40%	98%	Important	Add Trona or hyd. lime for hi-S coal.
Mercury MACT	Probably w. SCR	Certainly w. ACI	Critical	Projected coal is high in mercury.
NO_X Reduction	85% w. SCR	85% w. SCR	Important	County is now in ozone attainment.
PM 2.5 Emissions	Low	Very Low	Important	Less of an issue than ozone.
Visible Steam Plume	Yes	None	Low Priority	Not expected to be a concern.
O&M Cost / Performance				
Draft Loss	7" wg	15" wg	Low Priority	Accounted for in O&M cost comparison
Power Consumption	4400 kW	1600 kW	Low Priority	Accounted for in O&M cost comparison
Bag Replacements	None	3 - 5 years	Low Priority	Accounted for in O&M cost comparison
Trona / PAC Additive	Trona for SO_3	PAC for Hg	Low Priority	Accounted for in O&M cost comparison
Reagent and Waste Product				
Wastewater Treatment	Future	None	Important	WWT system is likely, maybe by 2015
Byproduct Disposal	Wet Stack	Dry Landfill	Low Priority	Dry landfill has higher O&M cost?
Reagent Cost, Utilization	Lower Cost	Higher Cost	Low Priority	Lime is more costly than limestone
Construction Considerations				
Wet Chimney Cost	Re-Line Existing	none	Low Priority	Stack re-lining not req'd for dry FGD
Draft System Mods	Replace ID Fans	Add Booster Fans	Low Priority	Existing ID fans in poor condition?
Tie-in Outage Duration	~ 6 weeks	~2 weeks	Low Priority	Longer outage for stack and ID fans
Evaluated Cost				
Capital Cost	$74M	$92M - $112M	Important	Includes direct costs only
Extended Outage Cost	$5M	-	Low Priority	for 6-week outage, both units
O&M Cost, NPV	$40M	$53M - $64M	Important	2009 $ for 10-year economic life
Total Cost	**$119M**	**$145M - $176M**	Important	

Has the Tipping Point Shifted?

- Must we now assume that a baghouse will be required for MACT on wet FGD?

- Should we now include the cost of wastewater treatment in the wet scrubber economics?
- How will anticipated regulations on disposal of Coal Combustion Residuals affect our plans?

Wet FGD + Baghouse vs. Dry FGD w. Baghouse
NPV Calculated over 20 Year Plant Life for 500 MW Plant A



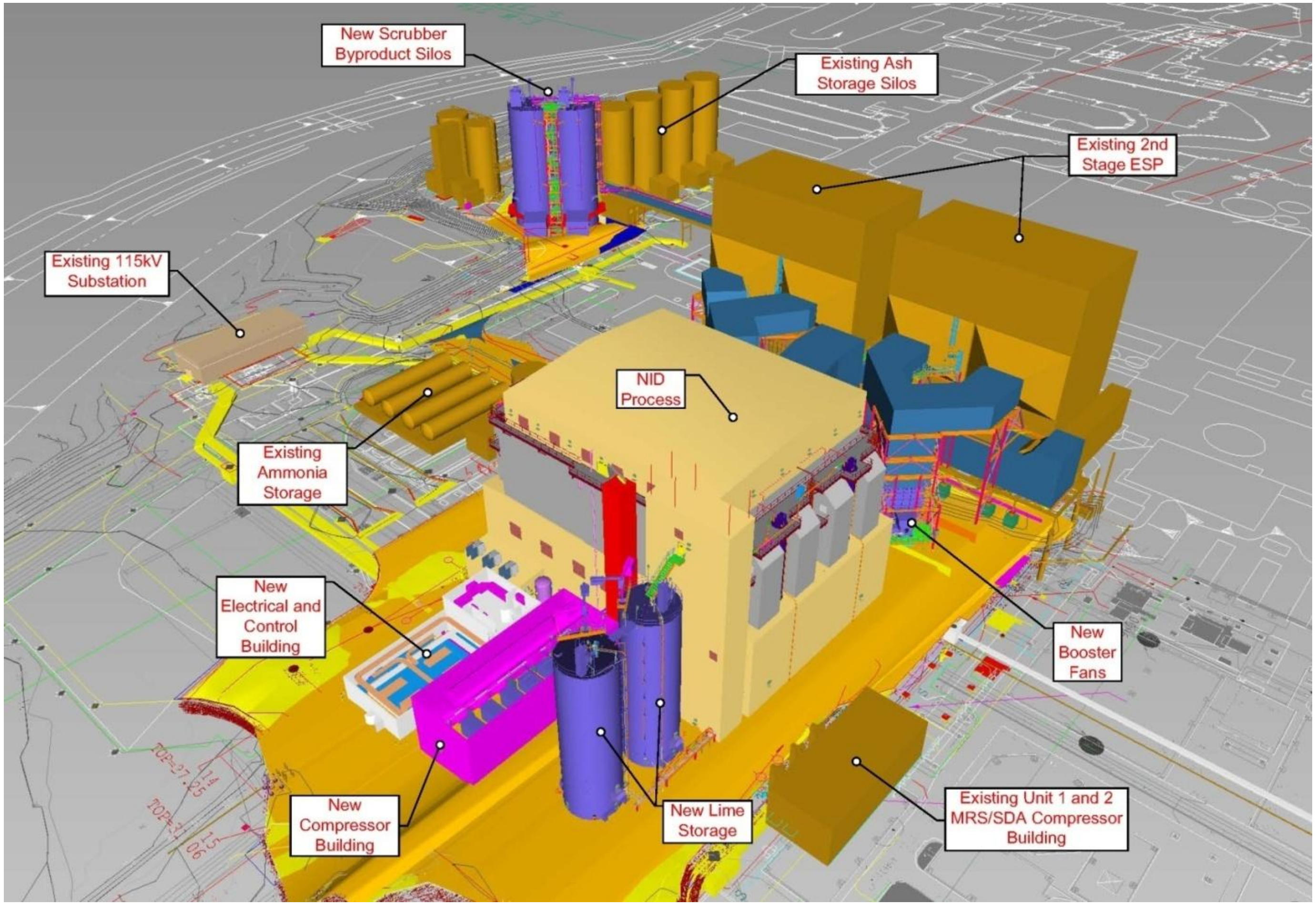
Case Study - Plants A and B

- Plant A – 2 x 250MW units, no other coal-fired generation on plant site
- Plant A would get a dry FGD system
- Better overall economics when a baghouse and wastewater treatment are included in the analysis

Case Study - Plants A and B

- Plant B – 375MW + 250MW units, one larger unit on the same site has a wet scrubber
- Plant B would get a wet FGD system
- Would replicate the existing wet scrubber to treat combined flue gas from both units.
- Shared reagent prep and gypsum disposal
- Shared O&M staff, parts inventory, etc.

On the Choice of a Dry Scrubber for Dominion's Brayton Point Power Plant



Presented by Thomas Penna, PE - Dominion Brayton Point Unit 3 Scrubber Project Manager **12/8/11**

- **Brayton Point Station is located on Mount Hope Bay, near Fall River, MA.**
- **Station comprised of three coal fired units, Units 1 and 2 – 250 MW each and Unit 3 – 630 MW, Unit 4 - 450 MW gas/oil fired unit, and five diesel generators.**
- **Existing air quality control systems include Babcock Power Environmental (BPEI) selective catalytic reduction systems on Units 1 and 3, Chemco mercury reduction systems on Units 1, 2, and 3, and Wheelabrator/Siemens spray dryer absorber (SDA) semi-wet scrubbers on Units 1 and 2.**
- **Unit 3 is a Babcock and Wilcox, opposed-fired, supercritical, double reheat boiler, with air heaters, two (2) sets of cold side electrostatic precipitators in series, ID fans, and a concrete stack with an acid brick liner.**

SDA vs. CDS Review

- Unit 1 and 2 SDAs operational by December 2008.
- Planning for Unit 3 scrubber started in early 2009 and initially considered rotary atomizer SDAs and circulating dry scrubbers (CDS).
- Wet scrubber technology could achieve high SO_2 removal rates, but was not considered cost effective based on the Unit 3 fuel sulfur content (0.5 to 2.5 lb SO_2/MMBTU) and treating purge stream.
- Contracted consultant to conduct a study comparing the SDA and CDS technologies.
- Dominion developed pro forma comparing CAPEX, annual variable O&M, annual fixed O&M, and fuel costs, and considered required duration for tie-in outage.
- Dominion held meetings with the SDA and CDS original equipment manufacturers (OEM) and visited U.S. installations.
- Dominion developed a ranking matrix based on CAPEX, O&M, constructability, performance, schedule, experience, and commercial risk.

Technology Decision

- SDA appeared to be the better technology for Unit 3 based on lower capital and annual O&M costs, performance based on fuel with a maximum of 2.5 lbs SO_2/MMBTU, domestic and international operating experience, operating facilities that are equal to or larger than required for Unit 3, contractor familiarity with SDA technology (less risk with design, construction, and contract guarantees), qualified and reputable OEMs, Station experience with operating and maintaining SDA type scrubbers. SDAs could achieve 90% SO_2 removal based on Station operating experience.
- Air permit negotiations with MADEP during 3Q 2009 indicated that future SO_2 emission rate could be based on Best Available Retrofit Technology (BART) level - 0.15 lb SO_2/MMBTU at stack or 95% removal, on a 30 day rolling average.
- Based on the high probability that a more stringent SO_2 emission rate would be enacted in the future, Dominion determined it would be prudent to pursue the dry scrubber technology with the highest SO_2 removal efficiency.
- The SDA scrubber technology was eliminated from consideration due to the removal efficiency (approximately 94% maximum based on OEM guarantees) which would limit the fuel sulfur content to 1.5 lb SO_2/MMBTU maximum.

CDS Performance

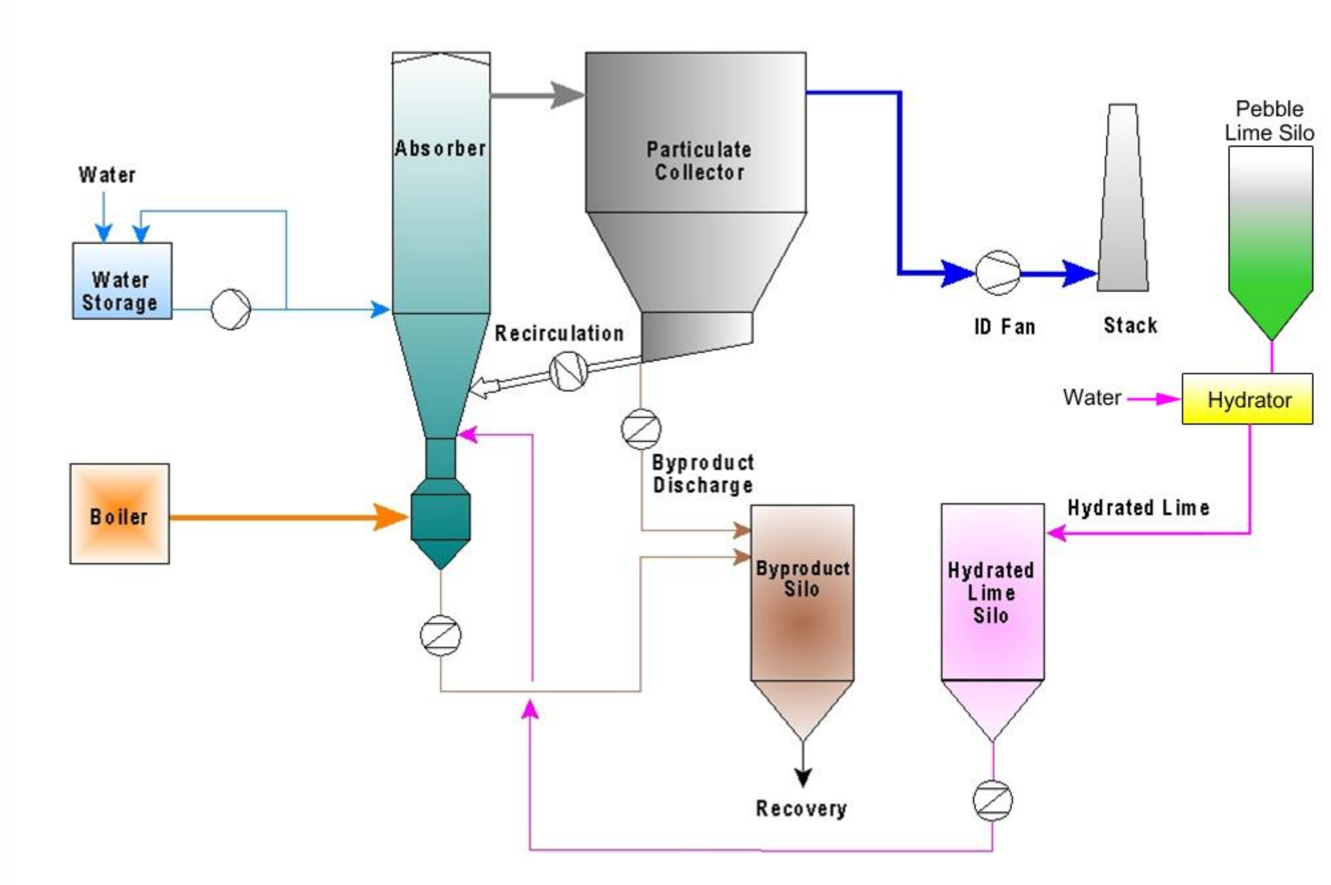
- **Pre-bid discussions with the CDS OEMS indicated the following emission guarantees could be achieved:**
  - **SO_2 Emissions: Continuously reduce SO_2 emissions to meet the least stringent of the following: maintain an emission rate of less than or equal to 0.05 lb/MMBTU SO_2 or 98% removal (rolling 30 day average) based on minimum, normal, and MCR operating conditions.**
  - **SO_3/Sulfuric Acid Removal: Continuously reduce SO_3/sulfuric acid emissions to less than or equal to 0.75 ppmdv @ 3% O_2 (0.00166 lb SO_3/MMBTU), based on minimum, normal, and MCR operating conditions.**
  - **Mercury Emissions (Unit 3 Air Permit Requirement): Continuously reduce mercury emissions to less than or equal to 0.0025 pound/gigawatt-hour net (1 hour average basis), based on an inlet concentration less than or equal to 0.0150 lb Hg/GW-hr net and on minimum, normal, and MCR operating conditions.**
  - **Particulate Emissions (Unit 3 Air Permit Requirement) : The maximum Filterable $PM/PM_{10}/PM_{2.5}$ rate shall not exceed 0.010 lb/MMBTU (1 hour block average) and the maximum Total $PM/PM_{10}/PM_{2.5}$ rate shall not exceed 0.025 lb/MMBTU (1 hour block average), based on minimum, normal, and MCR operating conditions.**

CDS Technology OEMs as of 2009

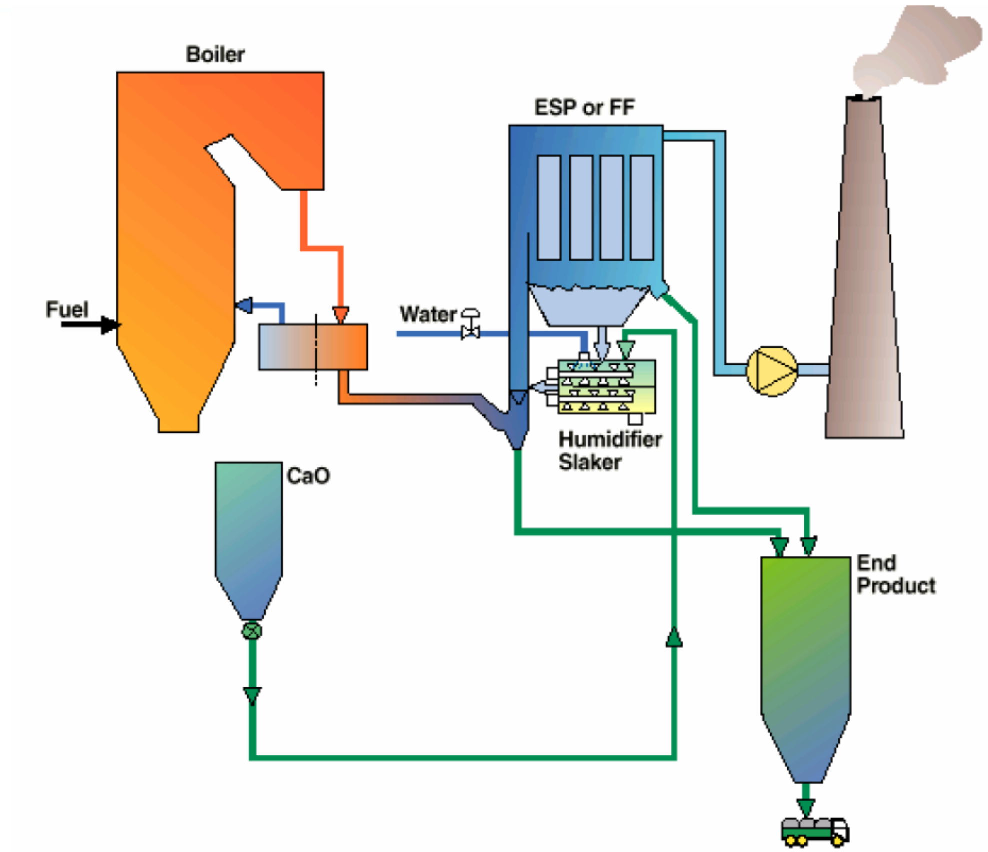
- BPEI – Licensee for Turbosorp technology (Austrian Energy & Environment)
  - Four (4) operating units in US and thirty eight (38) internationally.
  - Largest operating installation: 570,000 ACFM (China) – single train*.
- Allied Environmental – Licensee for Lurgi Lentjes Bischoff technology
  - Five (5) operating units in US and forty-two (42) internationally.
  - Largest operating installation: 1,120,000 ACFM – single train*.
- Nooter/Eriksen – Licensee for Graf-Wulff GmbH technology
  - Thirty five (35) operating units internationally – largest capacity is 2,400,000 ACFM (China) – two trains* .
- Alstom – novel integrated desulfurization (NID) technology ("J" duct design with mixer/hydrator)
  - Four (4) operating units in US and forty-one (41) internationally.
  - Largest operating installation: 840,000 ACFM – four reactors*.

* BPS U3 would be the largest domestic CDS installation – 2,400,000 ACFM.

Typical CDS Process



Alstom NID Process



- **Considering the SDA and CDS technology project costs to be comparable, the CDS technology offered fuel flexibility, allowed recovery from upset conditions as it pertains to the 30 day SO_2 emission rolling average (could operate at a higher removal rate), and minimized maintenance issues (no "atomizer change-out" or slurry issues).**
- **Dominion toured installations in the U.S. and Europe to verify advertised operation, identify potential maintenance or design issues, and confirm reliability.**
- **Dominion further reviewed equipment space requirements, and lime usage and byproduct production based on operating data provided by OEMs.**
- **Dominion determined that the four CDS OEMS would meet project specification requirements and equipment could be located within site footprint. Dominion issued the Engineering, Procurement, and Construction (EPC) RFP in September 2009.**
- **The EPC RFP allowed bidders to receive pricing from all four technology suppliers – no exclusive teaming. The EPC bidders performed due diligence and detailed cost analysis to determine the most cost effective technology.**
- **EPC contract was awarded in April 2010.**
- **The successful EPC Contractor selected the Alstom NID technology for the Unit 3 scrubber project.**

Questions

Please use the Q&A tab in LiveMeeting

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